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Project Summary

Evaluation of a Multifunctional Valve Assembly in a Direct Expansion Refrigeration System

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Tests of a multifunctional valve assembly were conducted in two types of supermarket display cases to investigate its performance and impact on energy use and package temperatures compared to conventional thermostatic expansion valves (TXV) that are presently used in these cases. The multifunctional valve assembly, which consists of an additional liquid line, the multifunctional valve, and a larger thermostatic expansion valve, was installed on all display cases of an instrumented supermarket refrigeration test rig. Tests were performed at various combinations of evaporating temperature (-30 or -27 °F), condensing temperature (75 or 105 °F), and defrost schedules (once per 24 or 48 hours) under either temperature or pressure control. Lower package temperatures were achieved under pressure control with the multifunctional valve assembly due to the lower superheats specified by the valve's manufacturer, although this reduction came at an energy penalty compared to the conventional TXV system. There was no energy or product temperature benefit seen with the multifunctional valve assembly under temperature control. Although the larger thermostatic valve in the multifunctional valve assembly resulted in shorter coil pull-down times after defrost, there was no impact on daily energy consumption. Both the multifunctional and conventional TXV systems performed well with one defrost per 48 hours, and each had about 4% energy savings compared to a more frequent defrost schedule. However, at this condition, the multifunctional valve showed no added benefit over the conventional thermostatic expansion valve.

This Project Summary was developed by the National Risk Management Research Laboratory's Air Pollution Prevention and Control Division, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

New expansion devices have the potential to improve the performance of supermarket display cases and, possibly, to reduce energy use. One suggested device is the multifunctional valve assembly. Tests of this valve assembly were requested to investigate its performance and impact on energy use and package temperatures compared to the performance of conventional thermostatic expansion valves that are presently used in supermarket display cases.

Test Equipment and Procedure

The multifunctional valve assembly, consisting of an additional liquid line, the multifunctional valve, and a larger thermostatic expansion valve, was installed on all display cases of an instrumented supermarket refrigeration test rig. The refrigeration test rig includes two low-temperature, single-deck display refrigerators; two two-door, reach-in cases; and a condensing unit with three unequal compressors, a water-cooled condenser, a water-cooled subcooler, an

oil management system, and a programmable controller. Tests were performed at various combinations of evaporating temperature (-30 or -27 °F), condensing temperature (75 or 105 °F), and defrost schedules (once per 24 or 48 hours) under either temperature or pressure control. For the multifunctional valve tests, superheats were set to 0-5 °F, per the manufacturer's instructions, while the baseline test superheats were 8-10 °F. The primary evaluation criteria were the product temperatures and the energy consumption.

The multifunctional valve assembly was first tested at the same conditions as earlier baseline tests and then at additional conditions which the manufacturer felt would demonstrate valve's benefits. These additional conditions included replacing the existing temperature controller, testing with one defrost per 48 hours, and testing under higher suction pressure. These new conditions required a few additional baseline tests to be performed after the multifunctional valve tests were completed.

Superheats for the multifunctional valve assembly tests could be properly adjusted only in pressure control when case solenoid valves remain fully open.

Results and Discussion

The multifunctional valve assembly tests were performed and compared to the baseline system. In some instances, comparisons are made to a few tests performed with the multifunctional valve removed but with the other assembly components (larger TXVs and additional liquid line) installed. These tests are considered to be performed on a modified baseline system. Test results are summarized in Table 1.

Pressure control tests

The multifunctional valve assembly uses 3% more energy than the baseline system, but package temperatures are about 1.5 R lower. These lower package temperatures are a result of the lower superheats specified by the valve's manufacturer for the multifunctional valve assembly tests, and this conclusion was verified by tests with the modified baseline system at the same low superheats, giving energy use and package temperatures comparable to the multifunctional valve assembly tests.

Temperature control tests

Energy consumption for both the multifunctional valve assembly and baseline tests were comparable under the original temperature control strategy (XTC1 and BSTC1). Package temperatures were slightly lower in the baseline system. The multifunctional valve assembly's energy consumption under the alternate temperature controller (XTC2) was about 1% higher, and reach-in case temperatures were colder than in the baseline tests.

Pull-down times after defrost, as defined by the coil reaching set-point to start solenoid valve cycling, were about 50% shorter in the multifunctional valve assembly tests than in the baseline tests. This was a result of the larger expansion valves and was verified in the modified baseline test, in which pull-down times were comparable to the multifunctional valve assembly tests. This faster pull-down time for the coil did not result in faster pull-downs for the packages.

Reducing the defrost schedule to once per 48 hours reduced the energy use of both systems by about 4% compared to one defrost per 24 hour. Energy consumption of the multifunctional valve assembly and baseline systems were comparable under a 48 hour defrost schedule although baseline tests showed slightly lower package temperatures.

Higher suction pressure

The valve assembly's manufacturer suggested that, since the multifunctional valve assembly tests under pressure control showed lower product temperature than the baseline system, the suction pressure could be raised in the temperature control tests with no degradation of product temperature, but with some energy savings. Suction pressure was raised by 2 psi to give a nominal evaporating temperature of –27 °F. At this condition, energy use was comparable between the multifunctional valve assembly and baseline systems, but package temperatures rose slightly with the multifunctional valve assembly tests compared to the baseline.

Higher condensing temperature

Energy use for both the baseline and the multifunctional valve assembly systems at 105 °F condensing were 30%

Table 1. Sumary of XDX Test Results

Test	Control	Evaporator °F	Condenser °F	Defrost Schedule	Energy kWhr/day	Case 1 °F	Case 2 °F	Case 3 °F	Case 4 °F
BSPC 1[a]	Pressure	-30	75	1 per 24 h	97.2	-14.1	-14.1	-6.7	-8.3
XPC 1[b]	Pressure	-30	75	1 per 24 h	101.2	-15.5	-15.5	-8.3	-9.9
BSTC 1[c]	Temperature	-30	75	1 per 24 h	97.9	-10.2	-10.2	-5.3	-7.1
XTC 1	Temperature	-30	75	1 per 24 h	97.0	-10.2	-10.2	-6.7	-6.7
XTC 2	Temperature	-30	75	1 per 24 h	98.7	-10.4	-10.4	-6.3	-6.4
BSTC 3 Avg	Temperature	-30	75	1 per 48 hr	94.0	-10.4	-10.4	-7.4	-7.7
XTC 3 Ave	Temperature	-30	75	1 per 48 h	93.5	-10.2	-10.2	-7.7	-7.8
BSTC 4	Temperature	-27	75	1 per 48 h	94.3	-10.4	-10.4	-5.1	-6.3
XTC 4	Temperature	-27	75	1 per 48 h	94.9	-9.8	-9.8	-5.1	-5.5
BSTC 5	Temperature	-27	105	1 per 48 h	125.9	-10.5	-10.5	-4.4	-6.7
XTC 6	Temperature	-27	105	1 per 48 h	105.5	10.0	10.0	4.5	6.0

[a] BS=baseline system tests; PC=pressure control; Test series 1
[b] X=multifunctional valve assembly tests
[c] TC=temperature control

higher than at 75 °F. Energy use for the two systems was comparable although the baseline system had lower package temperatures.

Conclusion

Lower package temperatures were achieved under pressure control with the multifunctional valve assembly due to the lower superheats specified by the valve's manufacturer. This reduction came at an energy penalty.

Under temperature control, the method used in field applications, there was no energy or product temperature benefit seen with the multifunctional valve assembly. Although coil pull-down times after defrost were shorter, there was no impact on daily energy consumption.

Both the multifunctional valve assembly and baseline systems performed well with one defrost per 48 hours, and each had about 4% energy savings compared to a more frequent defrost schedule. However, the multifunctional valve assembly showed no added benefit over the baseline at this condition.

Cynthia Gage *is also the EPA Project Officer (see below); G. Kazachki is with ARCADIS Geraghty & Miller, Durham, NC.*

The complete report, entitled "Evaluation of the XDX Valve Assembly in a Direct Expansion Refrigeration System," is available at http://www.epa.gov/appcdwww/apb/EPA600R04038.pdf or as Order No. PB2004-106606; Cost: $29.50, subject to change from:

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